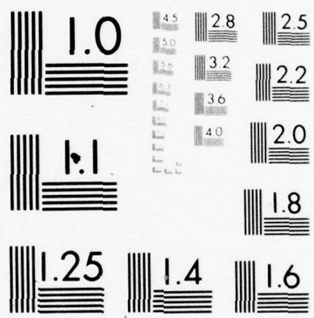
AD-A045 044 NAVAL MEDICAL RESEARCH INST BETHESDA MD F/G 6/18
BIOMEDICAL ASPECTS OF RADIO FREQUENCY AND MICROWAVE RADIATION: --ETC(U)
FEB 76 Z R GLASER, C H DODGE

UNCLASSIFIED NL

1 OF 1
ADA045044

END
DATE
FILMED
11-77
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

15

1. REPORT NUMBER	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) BIOMEDICAL ASPECTS OF RADIO FREQUENCY AND MICROWAVE RADIATION: A REVIEW OF SELECTED SOVIET, EAST EUROPEAN, AND WESTERN REFERENCES.	5. TYPE OF REPORT & PERIOD COVERED Medical Research Progress Report.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) ZORACH R. GLASER AND CHRISTOPHER H. DODGE	8. CONTRACT OR GRANT NUMBER(s) F51524; MF51524015
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Medical Research Institute, Bethesda, Maryland 20014	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS MF51.524.015.0030 Report No. 5
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Medical Research & Development Command, Bethesda, Maryland 20014	12. REPORT DATE February 1976
	13. NUMBER OF PAGES 33 (35p)
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Bureau of Medicine & Surgery, Department of the Navy, Washington, D.C. 20372	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release and Sale;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

249 650

18. SUPPLEMENTARY NOTES

Reprinted from: Biological Effects of Electromagnetic Waves: Selected Papers of the USNC/URSI Annual Meeting (Boulder, Colorado, October 20-23, 1975), Johnson, C. C. and Shore, M. L. (eds.), HEW Publication (FDA) 77-8010/8011, pps. 2-34, December 1976.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Radio frequency radiation	Radiation Bio-effects
Microwave radiation effects	Biomedical Review
Bibliography	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A survey of recent, selected Soviet and East European references reveals few new trends in the interpretation of the effects of radio frequency and microwave fields, at least at the clinical level. Soviet and East European investigators continue to report a variety of reversible changes in nervous and related functions which can occasionally be correlated with changes in animal behavior and organelle shifts under experimental (and clinical)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract (continued)

conditions. Western investigators, on the other hand, have been largely unsuccessful in repeating these findings under their own laboratory conditions until somewhat recently. There is now some evidence that some Western investigators are beginning to obtain certain functional and morphological data suggestive of Soviet and East European findings. Recent Soviet, East European, and/or Western experimental findings, coupled with the pressure of public opinion, may have a significant effect on their unique positions with regard to the occupational exposure levels. This report reflects the authors' continuing efforts to comprehensively compile the world literature on the subject, and complements an earlier review of the subject presented in Richmond in 1969. New emphasis has been placed on experimental and theoretical research.

BIOMEDICAL ASPECTS OF RADIO FREQUENCY AND MICROWAVE RADIATION: A REVIEW OF SELECTED SOVIET, EAST EUROPEAN, AND WESTERN REFERENCES

Zorach R. Glaser[+*] and Christopher H. Dodge[++]
[+]Naval Medical Research Institute Detachment, Naval Surface Weapons Center,
Dahlgren Laboratory, Dahlgren, Virginia 22448, and
[++]Science Policy Research Division, Congressional Research Service,
Library of Congress, Washington, D.C. 20540

ABSTRACT

A survey of recent, selected Soviet and East European references reveals few new trends in the interpretation of the effects of radio frequency and microwave fields, at least at the clinical level. Soviet and East European investigators continue to report a variety of reversible changes in nervous and related functions which can occasionally be correlated with changes in animal behavior and organelle shifts under experimental (and clinical) conditions. Western investigators, on the other hand, have been largely unsuccessful in repeating these findings under their own laboratory conditions until somewhat recently. There is now some evidence that some Western investigators are beginning to obtain certain functional and morphological data suggestive of Soviet and East European findings. Recent Soviet, East European, and/or Western experimental findings, coupled with the pressure of public opinion, may have a significant effect on their unique positions with regard to the occupational exposure levels. This report reflects the authors' continuing efforts to comprehensively compile the world literature on the subject, and complements an earlier review of the subject presented in Richmond in 1969. New emphasis has been placed on experimental and theoretical research.

INTRODUCTION

At the 1969 Symposium on the Biological Effects and Health Implications of Microwave Radiation held in Richmond, Va. [31], Dodge [40] and others [60A], reviewed the Soviet and East European literature in this field. At that time it was estimated that the literature amounted to several hundred citations, and that most of the data therein had not been brought to the attention of the United States scientific community.

Since that time several efforts have been made to better organize, consolidate, and disseminate the international literature on the general subject of the biological effects of microwaves [53, 98A]. Glaser's continuing efforts to this end have yielded a considerable data base on the subject [52]. The number of citations in the bibliography (dating as far back as the 1930's) is almost 3400, and the volume continues to grow rapidly.

There are a number of additional programs in the United States to develop automated or semi-automated storage and retrieval systems, not only for the literature, but for the specific data. Most of these systems are in various stages of formulation or final preparation. At least one additional bibliography on the subject has been published recently [60].

*Present Address: (See note at end of paper.)

The monographic and review literature on the biomedical aspects of radio frequency (RF) and microwave radiation has proliferated substantially since 1969. Most of the literature, however, has been generated by Soviet and East European sources [99, 108, 151, 158]. Some Soviet and East European works published in the 1968- 73 period are now available in the form of U.S. Government reports (National Aeronautics and Space Administration, Joint Publications Research Service, etc.), or hard-cover translations produced by private publishers [82, 88, 114]. The proceedings of the International Symposium on the Biologic Effects and Health Hazards of Microwave Radiation (Warsaw, 1973) have recently been published in English [32]. Reviews of international trends in the field continue to be published [56, 96, 97, 101].

Since 1969, the overall trend in this field has been far more harmonious than the period preceding when there was virtually no coordination between Soviet, East European, and Western scientists working in the area of RF and microwave bioeffects. Information is now transmitted more freely between international specialists. Moreover, data on the subject is now more generally available to the scientific community, and to the public at large than at any time in the past [165].

At the same time so much new data in the field is being generated so quickly on an international level [32, 152, 163] that the need for periodic attempts to review it have become more urgent, in our opinion. It is therefore the purpose of this review to selectively examine recent trends in the international literature on the biomedical aspects of microwave and radio frequency radiation. The purposes of this exercise are to determine: 1) whether recent data differs from earlier data because of new methodologies or other factors; 2) whether (because of item (1) or other factors) the disparity of opinion and differences in research emphasis between Soviet, East European, and Western specialists is being modified or "hardened"; and 3) what effects recent trends in the field might be having on theory in general, and on safety standards in particular.

THERMAL VERSUS NON-THERMAL THEORY

The most significant difference between East and West relative to biological mechanisms of effects of microwaves concerns the question of thermogenic versus nonthermogenic (or athermal) effects. (Or, as suggested at the Richmond Meeting in 1969, use of the term "microthermal effects".) The traditional Soviet and East European view from the earliest publications of bio-studies has been that microwave and radio frequency fields can functionally, and even morphologically in some cases, alter the organism at field flux or power densities below those which cause measureable heating in tissues or biological substrates. Thus, reversible changes in behavior, physiological function, and microstructures are frequently reported at power densities of microwatts per square centimeter ($\mu W/cm^2$), well below the Western world's "safe" exposure level of 10 milliwatts per square centimeter (10 mW/cm^2) [56, 88, 108, 114, 151, 158]. In contrast, the prevailing Western view, particularly in the United States, is that the effects of microwave and radio frequency fields are attributable only to the heating mechanism of those fields which are generally encountered at power densities in excess of 10 mW/cm^2 [96, 97, 98, 101, 125, 131, 132].

The disparity between Eastern and Western views in this respect finds its most eloquent expression in daily occupational exposure standards for microwaves. In the Soviet Union and some East European countries, the standard for an occupational exposure day is 0.01 mW/cm^2. (There is some question as to the adherence/measurement/etc. of these levels (particularly by the military, and by transportation and communication industries).) In the United States and some Western European countries, the value for continuous exposure is 10 mW/cm^2. Prior to 1953, it was believed that 100 mW/cm^2 was the lowest level at which

significant biological damage would occur [41]. Thus, 10 mW/cm^2 is approximately one tenth the level calculated to cause significant heating in human tissues, and agrees with physiologic and metabolic calculations. Intermediate standards between these values are practiced by some European countries as shown in Figure 1, and outlined in Table 1.

The reasons for this dramatic disparity between East and West on the mechanisms of microwave effects, and occupational standards for such radiation remain unclear, although dialogues of an international nature on the subject are beginning to flourish. This is an encouraging trend, since prior to 1969 there was virtually no dialogue between the two schools of thought.

The source of the disparity is complicated. On the Western side, it is argued that Soviet reports of nonthermal effects are poorly documented, incomplete in the presentation of experimental methodology and data, and faulty in the interpretation of experimental results or clinical findings. Some Western specialists contend that the many functional changes of a neurological or neuroendocrine nature frequently reported by Soviet and East European researchers are not necessarily inconsistent with well-known responses to general or local heating [96, 97, 98, 101, 147]. Indeed, some of the Soviet reports do contain data suggesting that some functional responses to thermogenic microwave fields are analagous to responses to supposedly non-thermogenic fields [108, 143]. Still others maintain that the electrical properties of biological systems are well understood on a quantitative basis, and that there is no evidence thus far presented to indicate the existence of nonthermal effects at the molecular or cellular level [131, 132].

On the Eastern side, it is argued that there is considerable experimental and clinical evidence to support the existence of nonthermal effects. A large number of Soviet and East European studies exist in which animals under experimental conditions, and humans under occupational conditions, are reported to exhibit marked (albeit reversible) functional changes, occasionally accompanied by histological and biochemical changes, under the chronic influence of microwave power densities ranging from fractions of microwatts to a few milliwatts per square centimeter [40, 56]. Some of this data is summarized in Table 2 (adapted from [40] and [56]).

While the diverse opinions on this point remain resolute, there appears to be one area of agreement between the two schools of thought: that certain biological structures, particularly those in the nervous system, may be selectively sensitive to thermogenic influences. Some Soviet and American studies indicate that some nervous system structures are more severely damaged by thermogenic microwave fields than others [1, 2, 151]. This suggests that these same thermally-sensitive structures might react to microwave power densities below the classically defined thermogenic threshold. Such a selective thermal sensitivity to microwaves, perhaps expressed as local or even microscopic heating (which is extremely difficult to measure) may explain many of the Soviet and East European findings [88, 114, 151, 158].

To summarize the controversy, many Western specialists are of the opinion that microwaves affect biological targets via strictly thermal mechanisms, whether the heating is on a generalized or local level. On the other hand, as articulated by Petrov [108], Soviet and East European specialists are convinced that electromagnetic fields in the microwave and radio frequency range exert two influences: thermal and nonthermal. At "high power densities" (in excess of 10 mW/cm^2), the effects are associated with the liberation of heat in biological objects with all the consequences thereof (i.e., heating of organs and tissues, thermal damage, etc.). At "low power densities" (less than 10 mW/cm^2) the physical mechanisms behind various biological effects remain unclear, but it is generally accepted in that community that nonthermal microwave effects do exist. In the paragraphs that follow, the data supporting both views is reviewed.

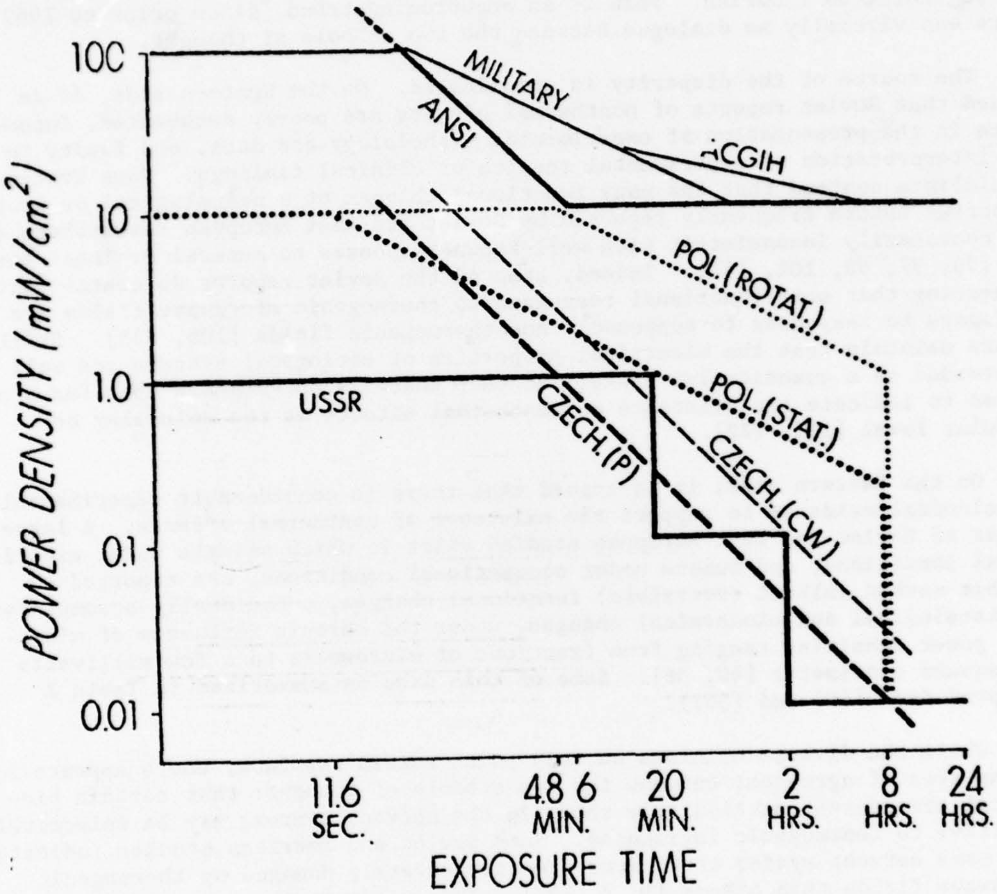


FIGURE 1. Microwave Personnel Exposure Standards.
[Adapted from Ref. 98B]

TABLE I

Personnel Exposure Standards for Microwaves
[From Ref. 98B]

Maximum Permissible Power Density (mW/cm^2)	Frequency (MHz)	Country or Agency	Specifications
10	10-100,000	U.S*	
		ANSI	1 mWh/cm^2, 24h
		OSHA	8 h workday
	100-100,000	ACGIH	10 mW/cm^2 TLV - 8 h 10-25 mW/cm^2, 10 min/h 25 mW/cm^2 - ceiling value
	300-300,000	Army/Air Force	10-55 mW/cm^2 min = $6000/(mW/cm^2)^2$
1	300-300,000	Poland	0.2 mW/cm^2-10 mW/cm^2 (8 h - 11.5 s) (SF)** 1.0 mW/cm^2-10 mW/cm^2 (8 h - 4.8 min) (NSF)
		USSR***	15-20 min/day
0.1		Poland	0.2 mW/cm^2, 8 h (SF) 24 h (NSF)
		USSR	2-3 h/day
0.025		Czechoslovakia	8 h (CW)
0.01		Poland	24 h (SF)
		USSR	8 h
		Czechoslovakia	8 h (pulsed)

*Also with slight modification - Canada, United Kingdom, German Federal Republic, Netherlands, France, Sweden.
**SF = stationary field (hr = $32/W/m^2$); NSF = nonstationary field (hr = $800/W/m^2$).
***MPE x 10 for exposure to movable beam or antenna.

Table 2

A SAMPLING OF THE GENERAL BIOLOGICAL EFFECTS OF MICROWAVES AT POWER DENSITIES OF 10 mW/cm^2 OR LESS (AS REPORTED BY SOVIET AND EAST EUROPEAN SOURCES)
[Adapted from Refs. 40 and 56]

	Clinical Effects [12,32,40,83,88,108]		Experimental Effects [9,10,11,55,56,74, 77,79,86,100, 103, 108,111,113,120,127 136,145,146,151]
I.	General subjective complaints (sensations, illusions, fatigue, loss of appetite, asthenia, etc.)	I.	Decreased physical endurance and retarded weight gain (rats)
II.	Functional CNS and perceptual changes	II.	General inactivation of CNS electrical activity; domination of hypothalamic function; altered afferent function (rabbits, cats)
			Inhibition of conditioned reflexes; increased motor activity; weakening of excitation/inhibition reactions; (rats, mice, birds)
			Morphological changes in nervous system (rats, guinea pigs, rabbits)
			Altered reactivity in response to drugs (rats, rabbits)
III.	Cardiovascular and associated autonomic changes	III.	Altered blood pressure and heart rate (rats, rabbits)
IV.	Altered blood chemistry	IV.	Altered blood neuroendocrine chemistry (rats, rabbits)
V.	Altered metabolism	V.	Altered amino acid and ascorbic acid metabolism (rats)
VI.	Depressed endocrine function	VI.	Altered reproductive cycle; decreased viability of offspring (rats)
VII.	Increased susceptibility to infectious diseases	VII.	Altered immune reactions (rabbits)

EFFECTS ON HUMANS

Comprehensive surveys of workers occupationally exposed to microwaves continue to be conducted in the Soviet Union and East European countries [35]. These surveys are of a broad-spectrum nature taking into consideration virtually all human vital functions. In contrast, few studies of this nature have been conducted in the West, and those that were usually concerned the effects of microwaves on particular organs, such as the eye. Nonetheless, it is worthy of note that early military surveys of microwave workers occasionally reported certain unexplained responses of man to radar fields, including nausea, epigastric distress, and various auditory and sensory nerve responses [164].

The results of the most recent Soviet and East European surveys are generally analagous to findings from earlier surveys, with the notable exception that they include more statistical data than in the past, which tends to enhance their credibility [40]. Soviet studies of occupational workers exposed to microwave power densities generally well below 10 mW/cm^2, continue to report various reversible functional changes in the nervous, cardiovascular, and blood systems which lead to a characteristic complex of symptoms. In fact, "microwave or radiowave sickness" has been isolated as a distinct clinical entity in the Soviet Union. Clinical responses usually are reported after chronic (approx. 3 to 6 years) exposure to microwave power densities ranging from several hundredths of a mW/cm^2 to "a few" mW/cm^2. As a rule, it has been observed that cessation of work involving exposure to microwave/RF radiation results in symptomatic stabilization, or recovery if such cessation takes place in the initial stages of symptoms. It is implied, however, in some studies that symptoms may stabilize or grow worse if exposure continues [126].

Neurological findings of personnel exposed to microwaves continue to receive considerable attention in the Soviet and East European countries. EEG changes have been consistently noted in Polish workers who have been exposed to microwaves. These changes, which include a lowering of the EEG alpha rhythm, are accompanied by decreased tolerance of neurotropic drugs [12]. Other studies have distinguished distinct "stages" of nervous system disturbance such as: 1) the neurasthenic syndrome with autonomic disorders; 2) pseudoneurasthenia with subjective complaints accompanied by symptoms of an organic nature; and 3) rare cases of encephalopathy. These changes are attributed to direct penetration of radiation into midline brain structures, as well as to selective thermal effects [78]. On the other hand, some East European surveys have failed to statistically correlate neurological or other general disturbances with either the degree or duration of occupational exposure to microwave radiation [138].

Changes in gonadic function have recently been reported in a Rumanian survey of workers exposed to centimeter waves at power densities ranging from tens to hundreds of mW/cm^2. A general decrease in sex function and spermatogenesis was noted in about 70 percent of the 31 workers surveyed. The findings are reported to be similar to earlier Soviet surveys [83].

Changes in the blood protein chemistry and the hematopoietic system of occupational workers are frequently reported in Soviet and East European clinical studies [106]. The changes are most often of a non-pathological nature, and seem to suggest a general reaction to stress, although one East European study has reported that human lymphocyte clutures exposed to low and moderately high microwave power densities show chromosomal changes suggestive of a mutagenic effect [141].

Soviet, East European, and Western clinical surveys of the eyes of workers occupationally exposed to microwaves continue to yield paradoxical data, particularly in comparison to experimental work on the subject. Some Western specialists suggest that the case histories of microwave workers who develop lens

opacities or cataracts are indicative of a long-term, non-thermogenic effect of this factor [159], although very recent surveys do not support this view [137]. A Swedish survey concluded that the pathogenesis of retinal lesions noted in workers is very obscure, and that the transmission properties of microwaves in biological tissues does not explain why certain targets of the retina should be more strongly affected than others. The general conclusion that the occupational standard of 10 mW/cm^2 might be too high was based on an increased incidence of lenticular and retinal changes encountered in the group surveyed [148]. An East European survey of lens translucency in various occupational and control groups suggested that long-term exposure to low intensity microwaves (below established cataractogenic power densities) may tend to accelerate the normal aging process of the lens [160]. Thus, while some Western and Eastern clinical specialists are convinced of damaging effects at chronically low levels of exposure, other experimental and clinical workers are as equally convinced that there is no proven case of microwave-caused cataractogenesis or other eye lesions [27, 137].

Dosimetric surveys of potentially hazardous microwave environments continue to be conducted both in the East [75, 102], and in the West [123, 139]. In the United States there has been recent emphasis on the microwave interference of electromedical equipment driving such vital human functions as the heart. One survey of a hospital near a new microwave transmitting tower concluded that the field strength seldom exceeded 1 V/m [122, 123], which is well below the Soviet exposure standard (0.01 mW/cm^2, or 5 to 6 V/m), and the U.S. exposure standard (10 mW/cm^2). Another study concluded that electromagnetic interference of implanted demand pacemakers does not presently constitute an important clinical problem. Of more than 2000 pacemaker patients surveyed, only 10 were mildly affected by electromagnetic field interference. None were fatally or seriously affected [139].

Finally, there are some who persist in the belief that microwaves at very low power densities (on the order of 1 mW/cm^2) can act psychophysiologically if properly modulated, and that certain unscrupulous governments (not named) are clandestinely involved in mind control thereby. One investigator believes that certain modulated radio frequency or microwave fields at 1 mW/cm^2 power density can be used to directly program verbal information into the brain via extra-auditory and extra-visual pathways. Elaborate experiments have been designed to support this hypothesis [130]. Thus far, there is little evidence to suggest that such a phenomenon is possible, with the possible exception of "microwave hearing" at low power densities [25, 43, 48A].

In summary, most clinical studies of a broad-spectrum nature of workers occupationally (or otherwise) exposed to microwaves, are being conducted in the Soviet Union and East European countries. These recent studies reflect an increased emphasis on the more rigorous statistical processing of data, and on the possible role of other environmental factors which may occur at working areas where microwave equipment is used. Because of this trend, and the added fact that supportive experimental research is reflexive to clinical findings in these countries (in contrast to experimentation in Western countries), the studies would seem to take on added significance. There remain problems of adequate and reliable dosimetry, and the problem of selecting adequate control groups to be used in clinical surveys; a situation common to most epidemiological studies. But the persistent findings that microwave workers exposed to relatively low power densities do seem to exhibit a variety of reversible neurological, cardiovascular, and regulative changes, occasionally of a disabling nature, warrants further epidemiological study, particularly in the West.

EFFECTS UNDER EXPERIMENTAL CONDITIONS

Neural Effects

There has been a recent trend in Western countries, most notably the United States, to investigate the biological effects of microwave and radio-frequency radiation below a power density of 10 mW/cm^2. At the same time, there has been no diminution of Soviet and East European activity in this sphere. Indeed, Eastern countries have traditionally devoted most of their investigative efforts to the study of animal neural responses to low power densities, in contrast to the United States and other Western countries, which until recently have been primarily concerned with power densities which cause gross heating in the organisms. An additional East/West contrast worth noting is the reason for the experimental research. In the East this research has been obviated by clinical findings, while in the West research has been of a more spontaneous nature, largely involving theory and thermal mechanisms of microwave effects.

There have been some attempts in the West to repeat Soviet and East European experiments, or otherwise eludicate the mechanisms by which microwaves at low power densities might affect behavior, neural function, or morphology. Behavioral work has been done in the West on a variety of animals including monkeys, rabbits, dogs, and small rodents. Monkeys exposed to 2450 MHz fields at power densities of between 5 and 25 mW/cm^2 did not exhibit changes in food-reinforced reflexes, in contrast to some Soviet and East European studies in which smaller animals have been reported to exhibit substantial changes in various reflexes when exposed to even weaker fields [49]. Rats exposed to 2.45 GHz fields (120 pulses/sec) and receiving power doses of 6.3 and 11 mW/g exhibited some task errors after exposure to the higher power density. Behavioral deficits were associated with mild to severe body heating [63]. Similarly, rats exposed to 1, 5, 10 and 15 mW/cm^2 of 2450 MHz pulsed and CW fields showed no changes in operant conditioned behavior in the 1 to 10 mW/cm^2 range [38]. At 15 mW/cm^2, the animals showed a significant decrement in performance which was associated with heat stress. In another experiment, subtle changes in performance patterns were observed in response to microwave levels as low as 5 mW/cm^2 [149]. Some Western data has therefore been obtained to indicate that small animals do respond behaviorally to microwaves at power densities below 15 mW/cm^2. Responses at these levels appear to be associated with thermal factors.

Quantitative measurements of neurological function have also been made in various Western experiments. Cats exposed to 147 MHz fields at 1 mW/cm^2 exhibited altered spontaneous and conditioned EEG patterns. In neonatal chick brains exposed to VHF fields, modulation rates lower than 9 Hz and higher than 20 Hz did not alter tagged calcium ion efflux. Exposure to fields modulated at 9, 11, 16, and 20 Hz resulted in a 10 to 20 percent increase in calcium ion efflux. The results of these experiments suggest that electrical forces induced in the brain tissue by low intensity VHF fields can trigger local conformational changes in the macromolecules of the outer zone of the neuronal membrane resulting in displacement of surface-bound cations [16, 17]. On the other, hand, rats exposed to 3 to 11 GHz microwaves at a power density of 1 mW/cm^2 exhibited no significant changes in the spontaneous electrical activity of the brain. This particular study suggested that low intensity microwaves of different frequencies and penetration depths had no influence on cerebral function as far as spontaneous activity was concerned [118]. At a higher power density (5 mW/cm^2), 3 GHz pulsed fields, after a few days of exposure, resulted in an electrocorticogram frequency which was identical to the pulse repetition frequency of the microwave field. It was conjectured by the investigator that microwave impulses were perceived by brain tissue as "electric shocks." This synchronization phenomenon appeared to be independent of EEG perturbations caused by microwaves [135]. A more recent study by this team, in which rats were exposed to a pulsed 9.4 GHz field with an

average power density of only 0.7 mW/cm^2, revealed some behavioral changes in the experimental animals. However, the short duration of the modulated pulses used in this experiment suggests that the irradiated animals might have been exposed to rather high (in excess of 10 mW/cm^2) peak power doses of radiation [51A].

Aplysia pacemaker preparations exposed to 1.5 to 2.45 GHz fields of less than 5 mW/cm^2 power density showed occasional functional changes, most of which could be reproduced by simple heating. However, in some cases, firing pattern changes resulting from microwave radiation were not reproducible thermally. It was conjectured that polarizing currents might be produced by microwave rectification [153].

Various changes in the EEG patterns of rabbits have been observed after exposures (of various duration) to 9.3 GHz microwaves at power densities of between 0.7 and 2.8 mW/cm^2. It was speculated that microwaves cause or enhance the formation of free radicals from naturally occuring compounds in the brain [54]. Finally, as will be discussed later, Western investigators have revealed morphological changes at the nerve cell level in small mammals exposed to microwaves of low power density [1, 2]. Thus, the results of Western research on the neural effects of low-intensity microwaves have been mixed, as has speculation concerning the mechanisms behind the results observed.

There have been persistent findings in the United States of human and animal auditory perception of low intensity microwaves [25, 43, 48A, 64, 71, 137A]. Cochlear cell structures appear to be of appropriate size and mass to be significantly perturbed by microwave field forces. This suggests to one investigator that a class of mechanisms exists whereby the direct auditory perception of pulse modulated microwaves with low incident power density can occur [85]. Others believe auditory perception of microwaves to be of a thermomechanical nature [43, 45A]. Thresholds for human perception of incident microwave pulses (1 to 30 msec) have been found to correspond to a pulse energy density of 40 mJ/cm^2 regardless of average peak power [58].

In Soviet and East European countries reports of a wide variety of neural responses to low intensity microwaves persist. The altered responses reported are of a behavioral, bioelectrical, functional, and histochemical nature. Behavioral changes are reported in response to low intensity microwaves (0.5 to 10 mW/cm^2). These changes are accompanied by depressed brain chemical activity (cholinesterase), and reversible lesions of cortical neurons, synapses, and neuroglia [86]. Functional disturbances at higher levels of the CNS are thought to be the result of lowered cortical tonus and altered integrative functions of central and subcortical parts of the brain. Both functional and morphological changes to low intensity microwaves appear to be reversible, and of a non-specific nature, compared to reactions to a variety of stresses [108, 151, 158]. Morphological changes at the nerve cell level are a persistent finding in Soviet studies [151]. Such changes are noted as a result of exposure of animals to power densities of from 0.06 to 20 μW/cm^2 in the microwave and radio frequency range in some studies [42, 56]. Similar morphological changes have also been noted after exposure to low intensity electric and constant magnetic fields [30, 55].

Soviet and East European investigators continue to find direct bioelectric evidence of the effects of both low and high intensity microwaves. EEG reactions to high intensity electromagnetic and magnetic fields have been found to be generally comparable to reactions to ionizing radiations, with the exception that early bioelectric responses to nonionizing fields differ from those to ionizing fields [30]. Studies of rabbits and rats exposed to 2 to 3 GHz microwaves at power densities of between 0.15 and 14 mW/cm^2, showed that lower power densities evoked auditory center electrical potentials. Only brain tissue

responded to these factors. When the rest of the body of the animal was irradiated, there was no response. It was speculated that these fields by-pass auditory receptors, and might be used to stimulate hearing in subjects with defective auditory analyzers [127]. In another Soviet study [142], rats with audiogenic epilepsy exposed to low intensity, pulsed electrostatic fields and microwaves showed decreased sensitivity to sound.

Pharmacological analyses of the effects of low intensity microwaves on neural function indicates that microwave effects depend on the activating influence of the ascending part of the reticular formation. Soviet and East European studies of personnel and animals chronically exposed to low intensity microwaves have revealed altered responses to neurotropic drugs [11, 12]. At least one Western study has reported similar results [134].

The biochemistry and histochemistry of neurological and neurochemical responses to microwaves is receiving considerable attention both in the East and in the West. There have been a number of Western studies of the effects of low intensity microwaves on serotonin, norepinephrine, and monoamine metabolizing enzymes [140], on neurotransmitters in general [94, 95, 159A] , on embryonic brain tissue [116], on the blood-brain barrier [105], and on nerve cells [57], as will be discussed in more detail later.

Microwaves at both low and high intensity are found to alter the uptake of phosphorus in nerve tissue, and to alter metabolic processes [55, 111]. Quantitative changes have been found in neurosecretory granules in cells of hypothalamic centers in animals exposed to low intensity microwave radiation, prompting the speculation that the harmful effects of microwaves on endocrine functions in general might be of hypothalamic origin [100].

Histological changes in nerve cells in response to exposure to microwaves are frequently associated with altered neurochemistry. One Western study has found that there is selective tigrolysis and vacuolization of neurons in certain parts of the nervous system exposed to 2450 MHz microwaves at power densities of 10 to 50 mW/cm^2 [1, 2]. This study, like a number of Soviet and East European studies conducted earlier, indicates that certain parts of the lower mammalian nervous system are more susceptible than others to microwave injury at rather low power densities [9, 10, 56, 151, 158].

Finally, it should certainly not be overlooked that a number of neural and behavioral responses of a variety of animals have also been reported as a result of exposure to extra-low and very-low-frequency electromagnetic fields, as well as to constant electric and magnetic fields [87, 93, 107, 129]. Experimental results in this sphere are interesting, though paradoxical; the results varying as a function of the biological target and experimental conditions. Behavioral responses of certain animals to field-free conditions have been reported [22], suggesting that the E and/or H component of the electromagnetic environment is necessary for orientation, navigation, and even the timing of biological processes. Human and animal neural responses to charged ions in the air [37, 84, 117], and to very weak, modulated DC currents [66, 128, 162], are also worthy of noting in the light of the reported responses to low intensity microwave and radiofrequency fields discussed in this review. Whether the low intensity field factors influence biological targets to any significant extent has yet to be determined.

While there is no unanimous international agreement as to the mechanisms of the many observed effects of microwave and radio frequency fields on neural targets, a number of trends seem to be emerging. First there is evidence from both Eastern and Western laboratories that radio frequency and microwave fields are selective in their neural tissue effects. That is, some neural targets are more sensitive to both low- and high-intensity fields than others. Second, there

would appear to be some agreement in the East and West that responses to microwaves are of a nonspecific nature. In other words, there is evidence that radio frequency, microwave, magnetic, electrostatic, and possibly even ionizing radiations at various high and low power levels have rather similar effects on neural targets which do not differ significantly from other stress factors. Of course, some unique neural effects of microwaves have been observed on both sides. Third, it is generally agreed that low-level radio frequency and microwave neural effects are reversible. Only in clinical studies of the East, involving prolonged (i.e., 2 to 6 year) occupational exposure to low level fields, is there any suggestion of long-lasting, persistent effects. Fourth, evidence in the East and West is accumulating that radio frequency and microwave fields have rather immediate and spontaneous effects which are reinforced by continued exposure.

A number of hypotheses have been offered as to the proposed pathways of microwave and radio frequency neural effects. As mentioned earlier, some Western specialists believe that the reported neural effects and behavioral effects are not necessarily inconsistent with thermogenesis [97]. This belief is supported by some Eastern findings that microwaves are selective in their effects on neural targets at both high and low intensities, and that low intensity effects are not substantially distinguishable from high intensity effects, or the effect of other stress factors [88, 108, 114, 151, 158].

The extrapolation of animal responses to the human condition is another factor fraught with difficulty. Little is known about the thermodynamics of human tissues, let alone animal tissues. Even the dynamics of animal body temperature are poorly understood. Therefore, it would seem to be possible that humans and animals can react quite differently to subtle thermal changes, with variance dependent on the individual tissue sensitivity or responsiveness to such factors. There is possibly a great deal of variation in tissue sensitivity from species to species, and even from organism to organism. Superimposed on these unknowns are the added unknown effects of other factors such as conditioned-, tactile-, auditory-, and visual-stimuli, in combination with radio frequency and microwave electromagnetic influences [72].

Some Eastern and Western specialists believe that an interaction can occur between glial and neuronal cells of the nervous system in response to microwave and radio frequency influences. These influences appear to modify the interaction between glial and neuronal elements inside certain neural structures. The neural effects of both high and low intensity microwave and radio frequency fields can be observed at the level of the cell, tissue, organ, or total organism. Moreover, the neural effects of these factors appear to be complex in nature, involving not only basic neural structures but also associated neurohumoral, psychological, and other factors [119]. These findings complicate the task of elucidating a specific mechanism or mechanisms of effect. As articulated by Justesen [72], "While he (the radiobiologist) is grappling with problems of physical artifact, he must come to understand that they are compounded by those of psychogenic origin. The antidote for both problems is well conceived and well controlled experiments in which the monitoring of temperature of intact animal subjects is no longer a nicety, but an imperative."

Ocular Effects

As mentioned earlier, there is general agreement that cataractogenesis in humans and animals can be caused by acutely thermal microwave and radio frequency radiation. What is not clear, however, is whether ocular damage in terms of lens or retinal lesions is possible after chronic exposure to field power densities of mild or nonthermogenic intensity. Attempts to clarify this issue in the laboratory have recently been made in the West. The rabbit has traditionally

been the preferred laboratory animal for these studies. In one study, the threshold for ocular damage appeared to be very high (300 mW/cm^2) when the entire body of the animal (with the exception of the head) was shielded. In unshielded animals, the lethal power density was found to be of a much lower value (between 25 and 50 mW/cm^2). The result of this series of experiments offered little support for the hypothesis that repeated sub-threshold exposure to microwaves causes a cumulative type of ocular damage. The results of similar experiments with dogs appeared to be roughly in quantitative agreement with rabbit experiments, suggesting that both animals are acceptable models of the human condition [4, 5].

Another study determined that cataractogenic power densities are also lethal [28]. The supposition that high intensity microwaves are indeed cataractogenic has recently been supported by slit-lamp biomicroscopic examination of the eye. Prominent ultrastructural changes in lenses exposed to acutely thermal 2450 MHz fields were observed [156]. High intensity (up to 200 mW/cm^2) microwaves were also found to decrease the ascorbic acid content of the rabbit lens. Ordinary heat had the same effect [155].

In an East European study, rats, rabbits, and roosters exposed to 2860 MHz microwaves with a power density of 120 mW/cm^2, showed altered corneal epithelium mitotic rates as a function of the time of day. Mitosis frequency increased after morning exposures but decreased after evening exposures. It was speculated that the variable sensitivity of the cornea to microwaves might be related to the intrinsic rhythm of mitosis. It was concluded that the cornea should be examined in personnel occupationally exposed to microwaves [99].

In an attempt to elucidate mechanisms of microwave cataractogenesis, normal and experimentally hypothermic rabbits were exposed to 2450 MHz microwaves at power densities of up to 200 to 400 mW/cm^2. Interestingly, cataracts were produced in uncooled animals, but not in hypothermic rabbits. Although a critical cataractogenic temperature was not found, no lens opacities were produced at retro-lental temperatures below 41°C. Similar results were obtained from experiments conducted on dogs [80].

The results of the majority of studies reviewed suggest that microwave damage to the eye is of a thermal nature, and that quite high temperatures are required to produce such damage. These studies do not support the belief (in some Eastern and Western circles) that occupational microwave fields can cause eye damage in humans; cataracts in particular. At present, according to one observer [27], there is no case in which microwave radiation has been the proven cause of a human cataract.

Effects on Blood Systems

Studies of the effects of high and low intensity microwaves on the blood and hematopoietic system have, for the most part, been limited to the Soviet Union and East European countries. In guinea pigs exposed 10 minutes per day for 30 days to 3 cm waves with a power density of 200 $\mu W/cm^2$, the osmotic resistance of leukocytes was found to decrease. The drug "pentoxil", a cancer chemotherapy agent (5-(hydroxymethyl)-6-methyl-uracil) which has a leukopoietic stimulating effect, was found to decrease the incidence and severity of this effect [76].

Animals exposed to SHF radiation (100 mW/cm^2; 4 minutes per day; 31 exposures) and exposed to gamma radiation (400 r; 23 r/min), exhibited altered hematopoietic function. SHF had an inhibitory effect on hematopoiesis which altered the reaction to gamma radiation, and modified the course of radiation sickness. While 19 days were required for hematopoietic recovery from gamma radiation, 39 days

were required for recovery from SHF radiation [150]. On the other hand, in other Soviet studies, millimeter range microwaves (0.6 to 8.0 mm, at field intensities of 1 to 75 mW/cm^2) intensified proliferative processes in the bone marrow, and weakened the harmful effects of x-rays and chemotherapeutic drugs [113, 136].

In East European studies, rabbits, guinea pigs, and mice chronically exposed to low intensity (1 to 2 mW/cm^2) 2950 MHz microwaves exhibited peripheral lymphocytosis, and signs of hematopoietic stimulation. Apparently lymphocytes react uniquely to certain modulated microwave fields which, in the opinion of Czerski, makes them an attractive object for studies of the effects of microwaves at the cellular level [33, 34]. Another study suggested that changes in the bone marrow and spleen of animals exposed to high intensity (100 mW/cm^2) microwaves were not of a purely thermal nature [120]. One Western study concluded that high intensity 2450 MHz microwaves (1.3 W/cm^2) had a clearly harmful effect on the bone marrow of rabbits under certain conditions, and suggested that the resulting anemia might be caused by an inflammation of the bone marrow, rather than by stem cell failure [157]. Such studies, therefore, indicate that microwave radiation can exert either stimulatory or inhibitory effects on hematopoiesis as a function of microwave power density, wavelength, or modulation.

Another Western study has revealed that both pulsed and CW microwave energy at power levels considerably below 10 mW/cm^2 increase blood-brain barrier permeability in animals [105]. This finding is interesting in light of the many reports previously discussed that exposure to low-intensity microwaves has a variety of neural and behavioral effects, and alters the response to drugs and other stresses.

Effects on Metabolic and Immune Processes

There have been recent Western studies of the effects of high intensity microwaves on metabolic processes. In one study, exposure to 2450 MHz microwaves (10 to 50 mW/cm^2) did not affect oxidation of Krebs cycle substrates and beta-hydroxybutyrate, respiratory control, oxidative phosphorylation, or the energy linked accumulation of calcium in isolated rat liver mitochondria [44]. However, rats exposed to thermogenic 26 MHz fields showed marked changes in plasma and tissue trace metals (including iron, zinc, calcium, and magnesium). Since such elements usually occur complexed to other materials, such as nucleotides, the thermal component of RF power absorption is speculated to cause several wide-ranging alterations which might serve as biological indicators of power absorption [125].

Immune processes have been found to be altered by exposure to low intensity microwaves. In one East European study, rabbits were chronically exposed to 3 GHz fields, with a power density of 3 mW/cm^2. After a 6-week exposure the reaction to experimental staphylococcal infection was rapid, whereas after 10 weeks of exposure, a markedly lowered reaction time was observed. In healthy animals irradiated only after infection, no significant changes were found when compared with control animals [145].

Effects on Reproduction and Development

Recent Western studies have indicated that electromagnetic, electric, and magnetic fields at low intensities can affect the reproduction of fowl. Chickens exposed to 260 MHz, 915 MHz, and 2.435 GHz microwaves, as well as to 60 Hz electric and magnetic fields, exhibited reduced egg production. Differences in fertility were not related to treatments. Hatch of fertile eggs, chick quality, sex ratios, and adult viability did not differ significantly from the controls,

except in the case of exposure to a magnetic field, where there was a consistent but unexplained predominance of females [81]. Similarly, quail eggs exposed to 2450 MHz, 30 mW/cm^2 microwaves did not exhibit any significant developmental changes from control eggs [91]. Thermogenic RF radiation (27 MHz) negatively affected the embryonic development of rats, and resulted in an increased incidence of embryo malformations [39]. A similar result was observed with insect pupae irradiated with nonthermal levels of 10 GHz CW microwaves [26].

In one Western study it was noted that low intensity microwaves (5 to 10 mW/cm^2) affect fetal development as a function of the time of day; the weight of fetal nerve tissue increasing after nocturnal exposure [116]. Teratogenic effects were noted in mouse fetuses exposed to 2450 MHz microwaves with a power density of 123 mW/cm^2 (3 to 8 cal/g dose) on day 8.5 of gestation [124]. Thus there is some evidence that microwaves can affect reproduction and development at high power densities.

Effects at the Cellular Level

There are continuing and increasing efforts, both in the East and West to elucidate the mechanisms of effects of microwaves at the molecular, subcellular, and cellular level. A few studies at this level have already been reviewed in this paper.

There have been recent Western studies of bacteria cultured under controlled conditions and exposed to low and high intensity microwaves. No effect, including mutagenic activity, could be found that could not be attributed to thermal factors in E. coli exposed to 1.70 to 2.45 GHz CW microwaves with a power density of between 2 μW/cm^2 and 50 mW/cm^2 [20, 21]. On the other hand, microwave frequencies between 40 and 150 GHz were found to selectively interfere with the synthesis of protein and DNA [154]. The effect appeared to be frequency dependent.

In an East European study, cell function and virus replication were investigated under the influence of 3 GHz microwaves at power densities of 5 and 20 mW/cm^2. No increase in temperature was noted in cell cultures. Increased replication of viruses was found in cells irradiated at 5 mW/cm^2, while decreased replication was noted at the 20 mW/cm^2 level [146]. Thus there would appear to be some evidence that low intensity microwaves can affect the basic genetic mechanism of simple single cell organisms.

A Soviet study investigated the effects of certain millimeter waves on cells and certain structural elements therein. A wavelength of 6.5 mm appeared to have the greatest effect. Altered red blood cell stability, altered nucleic acid and protein concentration, decreased chemoluminescence in liver cell nuclei and mitochondria, decreased viral infectious activity, and increased phage activity were observed. Cellular changes included cell wall disruption, protoplasmic degeneration, and an increase in cell size [77]. This range of millimeter waves, as previously noted, also affected hematopoiesis [113, 136].

An East European study observed that low intensity microwaves (1 mW/cm^2) disturbed the function of erythrocyte cell membranes after 15 minutes of exposure. It was speculated that the irradiation of cells in vitro with microwaves at low power densities, causes injury of the cell membrane function. The efflux of potassium from cells seems to be the first indication of such a disturbance [9]. A Western study of cell metabolism under the influence of prolonged (160 hour) 3.1 GHz microwaves (2 mW/cm^2), found that there was a marked increase in protein synthesis in the liver, thymus and spleen. Further studies are planned to elucidate the mechanism of this effect using tagged isotopes [103].

In another recent Western investigation, a low intensity microwave field (about 5 mW/cm^2) was found to evoke early transient and reversible changes in frog muscle membrane, particularly as related to the excitation and generation of the action potential and its propagation. A transient increase in the sodium ion current in the vicinity of the membrane was noted, which indicated an excitation phenomenon not necessarily associated with heating [112]. Still another study found that low intensity microwaves (10 mW/cm^2) alter neurochemical processes in lower mammals. There was a marked slowing of serotonin turnover rate, and a decrease in the firing rate of individual serotonin-dependent neurons [57]. Since these neurons are known to participate in the regulation of sleep and wakefulness, as well as in body temperature regulation, these findings may account for the various behavioral and functional effects of low intensity microwaves reported by many Soviet and East European researchers. An examination of the sleep states of microwave irradiated rabbits [87A], and of the effects of microwaves on drug-induced sleeping time in the rabbit [31A] have recently been reported. Finally, pulsed thermogenic microwaves (1 μ sec pulses, 20 pps; 2.7 GHz) were thought to cause damage to embryonic fish cell systems. Data and power measurement are still being developed [115].

While a number of theoretical studies and models have been developed to attempt to elucidate how microwaves interact with biological systems at the cellular and molecular level [47, 57, 65], reasons for the various microwave effects reviewed in this paper remain elusive. While many researchers are convinced on the basis of the available data that there are low intensity microwave interactions both at the microscopic and macroscopic level, others are as equally convinced that there is no basis for low intensity microwave effects, particularly at the molecular or cellular level. However, it is acknowledged by certain spokesmen for the latter school of thought, that forces which can be generated by the application of alternating fields (such as field-evoked forces, dielectrophoresis, and electromechanical effects), may well be responsible for such phenomena as the auditory perception of weak, pulsed microwaves, and hence, many of the behavioral effects reported in the 1 to 10 mW/cm^2 range [132]. In general, it would appear that recent Western research on cellular systems is yielding data suggesting that even more complicated interactions between microwaves and certain biological substrates are possible [47].

DOSIMETRY AND EXPERIMENTAL METHODOLOGY

Progress has been made since 1969 in the quantitation of the fields associated with exposure of biological specimens to electromagnetic radiation, in the related experimental methodology, and in the definition and standardization of concepts and terminology [70, 73]. Thermographic recording has been used to measure surface temperature of exposed hairless animals [121], and of animal carcasses and phantom models [59, 67]. Significant advances have been made in the development of probes and meters to measure power density in a radiation-type field, or the square of the electric field intensity in a near-zone field [6, 23, 62]. Developments in the determination of power density, electric field, or temperature within the irradiated biological tissue have been described [14, 15, 67]; particularly interesting are the fiberoptic liquid crystal temperature probe [68, 161], the use of implantable microwave diodes [24], and the application of color thermography and microwave radiometry to biological systems exposed to microwave radiation [19].

Comments have been made on the methods of calibrating microwave hazard meters and the uncertainties associated with each method [8, 144]. Frank [46] pointed out some of the technical problems associated with the determination of environmental hazards from microwave sources. Microwave dosimetry involving biological response indicators has been discussed [36, 88A, 109]. Progress has been made in the areas of: determination of the dielectric properties and

electromagnetic wave propagation parameters through biological tissue [110, 132]; microwave reflection and diffraction effects caused by the biological target [18]; the dependence of whole animal absorption on polarization and frequency [50]; theoretical calculations of power absorption in phantoms (i.e. modeling), [3, 48, 51, 89, 104]; absorbed dose distribution in phantoms [61]; the assessment of power deposition in tissues by numerical methods [13, 45]; and the development of non-perturbing miniature electric field probes which are implantable in muscular tissue [29].

Increased use has been made of waveguide exposure systems, specific mode cavity-type chambers, and stripline (as opposed to the free-space plane-wave situation) in which to irradiate specimens [7, 92]. We have seen increased standardization of instrumentation and analytical techniques to permit better determination of the exposure conditions [69], and a plea for the use of such important concepts as the "absorbed dose", "absorbed dose rate", and "specific absorption rate".

Sevast'yanov [133] described an interesting method of visually determining microwave (EHF, 3 GHz) beam cross section, or of locating microwave leakage from generating equipment using thermoreactive paper.

The excellent 1974 review by Minin [102] contains a lengthy and detailed chapter entitled "Techniques of radio frequency measurements; Apparatus and methods ", in which Soviet electric field measuring equipment (such as the PO-1, P3-9, IP-3425, and IP-3466 field-measuring instruments) are described. The chapter mentions the routine measurement of power levels of between 10 $\mu W/cm^2$ and 200 mW/cm^2, discusses measurements of fields aboard ships and aircraft, and describes dosimeters, a radioprotective suit, and a protective face mask. Unfortunately, of the 207 references given, only 56 citations date since 1969 (of which 20 were 1969, and 18 were 1970). We are left, therefore, with the feeling that very little recent Soviet and East European work in the area of dosimetry and related experimental methodology has been published (if it is being performed).

Thus, with only a few exceptions [75], the majority of the activity since 1969 (as evidenced by published reports in the literature) in the area of dosimetry and experimental methodology appears to have come from the West.

DISCUSSION AND CONCLUSIONS

The gap between East and West remains large with regard to clinical findings. Soviet and East European clinical surveys of occupational workers continue to report the usual plethora of physiological, neurological, and behavioral responses to extremely low-level fields. It still remains a matter of curiosity that there are few Western occupational surveys against which to evaluate this data. Those few surveys which have been conducted do not report data comparable to those from the East. There appears to be little new support for the assumption that microwaves affect humans via any extra-thermal mechanism, despite continuing speculation in some circles that chronic exposure to low-level fields can cause lens opacities and certain other reversible functional changes.

Some experimental research in the West is yielding data suggestive of that from Soviet and East European scientists. Neural responses reported in Western studies are now frequently documented in small animals exposed to microwave and radio frequency fields of less than 10 mW/cm^2 intensity. These responses, including changes in cell membrane function, nerve tissue histology, and "hearing" sensations, appear to be associated with thermogenesis. At the same time, Soviet and East European researchers continue to report a multiplicity of neural and other responses to low-level fields which are not necessarily associated with thermogenesis, but most important, not necessarily dissociated from thermogenesis

either. Low-level microwave effects are frequently indistinguishable from thermal effects in those studies. Both East and West continue to report changes occurring at the organ and organelle level in response to low-level fields. We note that the increasing frequency of Western findings tends to increase the credibility of similar findings from Eastern countries.

There appears to be a slight convergence of Eastern and Western findings with regard to low-level microwave and radio frequency field effects. Western researchers, like their Eastern counterparts, are revealing subtle responses to low-level fields which suggest that some organs and organelles are more sensitive to the effects of microwaves and radio frequency fields than others. Western researchers are also reporting behavioral responses to low-level fields suggestive of those reported by Soviet researchers. It is noteworthy that ten years ago such findings would have been regarded almost as heresy in the United States. At the same time, Soviet and East European researchers appear to be modifying their defense of the concept of "nonthermal" effects, which suggests that an acceptance would bring East and West significantly closer together conceptually.

With regard to occupational standards, there also appears to be developing a trend toward East-West convergence. If the trends in Western research reported above continue, it is not difficult to speculate that the United States' endorsed occupational exposure level of 10 mW/cm^2 per day might be lowered to 5 mW/cm^2. However, additional occupational surveys are needed before such a significant judgement can be made, since extrapolation of experimental data to man remains very risky. At the same time, we note that the extremely conservative Soviet standard (0.01 mW/cm^2) is not a particularly defensible one, and that there is a trend in some East European countries to relax this standard by as much as an order of magnitude. If such a trend continues to develop as anticipated, the large disparity between occupational standards in the East and West will be substantially narrowed. This is the same conclusion reached by Marha in 1971 [87B].

Significant progress has been made in the area of experimental methodology and dosimetry. The published reports appear to come predominately from the West. As Czerski [36] so aptly states, however, "Recent advances in microwave dosimetry and design of exposure systems for biological objects are not accompanied by the same rate of development in biological experimentation and in the understanding of microwave biological effects."

There has been recent concern in the West on the possibility of microwave interference with electromedical equipment driving such vital human functions as the heart. We're now seeing reports of <u>negative</u> experimental results (from the West). Not a single report appeared during the four Tri-Service Meetings. Only one negative report (from Poland) appeared at the recent Warsaw Meeting, and none have come from the USSR. We note continued interest in therapeutic application of microwaves, with recent emphasis in the field of cancer therapy. The question of "effects analysis" is being differentiated from "hazards evaluation".

We note that there is increased international exchange of information in the microwave/RF bio-effects field (both personal and impersonal), than was the case six years ago. Likewise, the availability of foreign literature in the United States has been substantially improved in recent years. Both trends are amenable to improvement, however. For example, a centralized data base in this field should be more exploitable by the scientific community. In addition, efforts should be made to more frequently review international trends in the field because of the increasing volume of data. To this end, we suggest the establishment of an international "Review of Electromagnetic Radiation Biology and Medicine", to be published on a bi-annual or quarterly basis, and to contain articles primarily of a review nature. Such a journal might be administered under the aegis of the World Health Organization (or some other international health organization).

ACKNOWLEDGEMENT

The authors acknowledge the outstanding assistance of Mrs. Patricia Brown in the preparation of this paper, and Dr. Joseph Hosszu for critically reading the manuscript.

The opinions or assertions contained herein are the private ones of the authors and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large, nor of the Congressional Research Service, Library of Congress.

REFERENCES

1. Albert, E.N., & DeSantis, M., "Do microwaves alter nervous system structure?" IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:87-108, February 28, 1975.

2. Albert, E., "Light and electron microscopic investigation of brains exposed to non-ionizing radiation." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 224 only.

3. Allen, S.J., "Measurements of power absorption by human phantoms immersed in radiofrequency fields." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:494-498, February 28, 1975.

4. Appleton, B., "Experimental microwave ocular effects." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 186-188.

5. Appleton, B., Hirsch, S.E., & Brown, P.V.K., "Investigation of single-exposure microwave ocular effects at 3000 MHz." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:125-134, February 28, 1975.

6. Aslan, E., IEEE Trans. on Instrum. & Meas., "Broad-band isotropic electromagnetic radiation monitor," IM-21(4):421-424, November 1972.

7. Baillie, H.D., "Rapid warming from hypothermia by microwaves." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.) , Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 15-23.

8. Baird, R.C., "Methods of calibrating microwave hazard meters." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 228-236.

9. Baranski, S., "Histological and histochemical effect of microwave irradiation on the central nervous system of rabbits and guinea pigs," American Journal of Physical Medicine, 51(4):182-191, 1972.

10. Baranski, S., Szmigielski, S., & Moneta, J., "Effects of microwave irradiation in vitro on cell membrane permeability." IN: Biologic Effects and Health Haz. of Microwave Rad. (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 173-177.

11. Baranski, S., & Edelwejn, Z., "Pharmacological analysis of microwave effects of the CNS." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 119-127.

12. Baranski, S., & Edelwejn, Z., "Experimental morphologic and electroencephalograph studies of microwave effects on the nervous system." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:109-116, February 28, 1975.

13. Barber, P.W., "Numerical study of electromagnetic power deposition in biological tissue bodies." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 229 only.

14. Bassen, H., Swicord, M., & Abita, J., "A miniature broadband electric field probe." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:481-493, February 28, 1975.

15. Bassen, H., "An optically linked telemetry system for use with electromagnetic hazard probes," Conf on Precision Electromagnetic Measurements, London, 302- , (July 1974).

16. Bawin, S.M., Kaczmarek, L.K., & Adey, W.R., "Effects of modulated VHF fields on the brain and spinal cord of cats." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247: 74-81, February 28, 1975.

17. Bawin, S.M., & Adey, W.R., "Effects of weak low frequency electric fields on calcium efflux from isolated chick and cat brain." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 267 only.

18. Beischer, D.E., & Reno, V.R., "Microwave energy distribution measurements in proximity to man and their practical application." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:473-480, February 28, 1975.

19. Bigu del Blanco, J., & Romero-Sierra, C., "Colour thermography and microwave radiometry: Their application to biological systems under microwave radiation exposure," Proceedings of the 1975 IMPI Symposium, Waterloo, Ontario, Canada.

20. Blackman, C.F., Benane, S.G., Weil, C.M., & Ali, J.S., "Effects of nonionizing electromagnetic radiation on single cell biologic systems." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:352-366, February 28, 1975.

21. Blackman, C.F., Surles, M.C., & Benane, S.G., "The effect of microwave exposure on bacteria: mutation induction." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 134-135.

22. Bliss, V., & Heppner, F., "Effects of the field-free space on the circadian activity rhythm of the house sparrow, Melospiza melodia." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 268 only.

23. Bowman, R., "Some recent developments in characterization and measurement of hazardous electromagnetic fields." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 217-227.

24. Bowman, R., As cited by Guy, A.W., IN: AGARD Lecture Series No. 78 on Radiation Hazards (Sept. 1975), Chapt. 9 entitled "Engineering considerations and measurement."

25. Cain, C.A., & Rissmann, W.J., "Microwave hearing in mammals at 3.0 GHz." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 35 only.

26. Carpenter, R.L., & Livstone, E.M., "Evidence for the nonthermal effects of microwave radiation: abnormal development of insect pupae," IEEE Transactions, MTT-19(2):173-177, (1971).

27. Carpenter, R.L., Ferri, E.S., & Hagan, G.J., "Assessing microwaves as a hazard to the eye— progress and problems." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 178-185.

28. Carpenter, R.L., "Use of a dielectric lens for experimental microwave irradiation of the eye." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:142-154, February 28, 1975.

29. Cheung, A.Y., Swicord, M.L., & Bassen, H.I., "Experimental calibration of a miniature electric field probe within muscular tissues." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 278-279.

30. Chizhenkova, R.A., "The role of different brain formations in EEG reactions of rabbits to a CMF and to UHF and SHF fields," Zhurnal vysshey nervnoy deyatel'nosti, No. 2, 313-321, 1962 (JPRS #64532).

31. Cleary, S.F., ed., Biological Effects and Health Implications of Microwave Radiation, Symposium Proceedings, 17-19 September 1969, Richmond, Va., BRH/DBE Report No. 70-2 (1970).

31A. Cleary, S.F., "The effects of 1.7 and 2.45 GHz microwaves on drug-induced sleeping time in the rabbit." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 193 only.

32. Czerski, P., Silverman, C., Ostrowski, K., Suess, M.J., Shore, M.L., & Waldeskog, B. (and Shalmon, E.), eds., Biological Effects and Health Hazards of Microwave Radiation. Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, Warsaw, 1974 (350 pps.).

33. Czerski, P., Paprocka-Slonka, E., Sierkeirzynski, M., & Stolarska, A., "Influence of microwave radiation on the hematopoietic system." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 67-74.

34. Czerski, P., "Microwave effects on the blood forming system with particular reference to the lymphocyte." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:232-242, February 28, 1975.

35. Czerski, P., et al., "Health surveillance of personnel occupationally exposed to microwaves, Parts I, II, III," Aerospace Medicine, 45(10):1137-1148 (1974).

36. Czerski, P., "Experimental models for the evaluation of microwave biological effects," Proceedings of the IEEE, 63(11):1540-1544 (Nov. 1975).

37. Deleanu, M., et al., "Effect of negative air ion exposure on adaptation to physical effort in young sportsmen." IN: Biometeorology (Landsberg, H.E., et al., eds.), 6, Part 1 (Supplement to 19, 1975 of the International Journal of Biometeorology).

38. Diachenko, J.A., & Milroy, W.C., "The effects of high power pulsed and low level CW microwave radiation on operant behavior of rats," Naval Surface Weapons Center, Rept. (NSWC/DL TR-3230), Dahlgren Lab., Dahlgren, VA, 1975.

39. Dietzel, F., "Effects of electromagnetic radiation on implantation and intrauterine development of the rat." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247: 367-376, February 28, 1975.

40. Dodge, C.H., "Clinical and hygienic aspects of exposure to electromagnetic fields: A review of Soviet and Eastern European literature." IN: Biological Effects and Health Implications of Microwave Radiation, Symposium Proceedings (Cleary, S.F., ed.), 17-19 September 1969, BRH/DBE Report No. 70-2 (1970), 140-149.

41. Donnelly, W.H., & McCullough, J.M., "Microwave radiation and environmental health— A brief review and bibliography," Library of Congress, Congressional Research Service, Rept. No. 71-198 SP, Washington, DC, August 27, 1971, 25 pps.

42. Dumanskiy, J.D., & Sandala, M.G., "The biologic action and hygienic significance of EMF's of superhigh and ultrahigh frequencies in densely populated areas." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 289-293.

43. Eichert, E.S., & Frey, A.H., "RF sound: possible mechanisms as defined by recent research." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 38 only.

44. Elder, J.A., & Ali, J.S., "The effect of microwaves (2450 MHz) on isolated rat liver mitochondria." IN: Biologic Effects of Nonionizing Radiation, (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:251-262, February 28, 1975.

45. Emery, A.F., Guy, A.W., Kraning, K.K., & Short, R., "Numerical simulation of the effects of non-ionizing microwave radiation upon the human body." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 231 only.

45A. Foster, K.R., & Finch, E.D., "Microwave hearing: Evidence for thermoacoustic auditory stimulation by pulsed microwaves," Science, 185(4147):256-258 (19 July 1974).

46. Frank, Z., "Radiation hazards from microwave sources with mobile antennas: certain technical problems." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 240-242.

47. Frazer, J.W., "A summary of cell and tissue level events produced by RF fields predicted from consideration of regional hyperthermia." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 132 only.

48. Frazer, J.W., MacDougal, J., Webb, M., & Guy, A.W., "Models of biologic interaction with electromagnetic fields." IN: United States National Committee/ International Union of Radio Science, Progaram and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 201-202.

48A. Frey, A.H., & Messenger, R., Jr., "Human perception of illumination with pulsed ultrahigh-frequency electromagnetic energy," Science, 181:356-358 (27 July 1973).

49. Galloway, W.D., "Microwave dose-response relationships on two behavioral tasks." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:410-416, February 28, 1975.

50. Gandhi, O., "Conditions of strongest electromagnetic power deposition in man and animals," IEEE Trans. on Microwave Theory & Techniques, MTT-23(12): 1021-1029 (Dec. 1975).

51. Gandhi, O.P., Sedigh, K., Beck, G.S., & Hunt, E.L., "Distribution of electromagnetic energy deposition in models of man with frequencies near resonance." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 201 only.

51A. Gillard, J., Servantie, B., Bertharion, A.M., Servantie, A.M., Obrenovitch, J., & Perrin, J.C., "Study of microwave-induced perturbations of the behaviour by the open-field test of the white rat." IN: United States National Committee/ International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 192 only.

52. Glaser, Z., Sixth Supplement** to Bibliography of Reported Biological Phenomena ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation; EMR Project Office, Naval Medical Research & Development Command, July 1975 (NMRDC Rept. No. 3), (AD #A015-622). [5th Supplement, July 1974, AD #784-007; 4th Supplement, June 1973, AD #770-621; Revised report, (April 1972), containing 1st Supplement (October 1971), 2nd Supplement (November 1971), & 3rd Supplement (April 1972), AD #750-271; Original report, October 1971, AD #734-391].

53. Glaser, Z.R., "Studies on the biomedical effects of microwave radiation: Past, present and future." Proceedings of the International Microwave Power Institute "Microwave Power Symposium", Marquette University, Milwaukee, Wisconsin, 28-31 May 1974.

54. Goldstein, L., & Sisko, Z., "A quantitative EEG study of the acute effects of X-band microwaves in rabbits." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 128-133.

**See note at end of paper.

55. Goncharova, N.N., & Miscenko, L.I., "Effect of an electromagnetic field in the meter range on the nervous system of animals based on physiological and biochemical studies," Gigiyena truda i professional'nyye zabolevaniya, No. 7, 122-124 (1973) (JPRS #60608).

56. Gordon, Z.V., Roscin, A.V., & Byckov, M.S., "Main directions and results of research conducted in the USSR on the biologic effects of microwaves." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 22-35.

57. Grodsky, I.T., "Possible physical substrates for the interaction of electromagnetic fields with biologic membranes." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247: 117-124, February 28, 1975.

58. Guy, A.W., Chou, G.K., Lin, J.C., & Christensen, D., "Microwave induced acoustic effects in mammalian auditory systems and physical systems." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:194-218, February 28, 1975.

59. Guy, A.W., "Analyses of electromagnetic fields induced in biological tissues by thermographic studies on equivalent phantom models," IEEE Trans. Microwave Theory & Tech., MTT-19(2):205-214, February 1971.

60. Harrison, E.A., Biological Effects of Microwaves: A Bibliography with Abstracts. National Technical Information Service, Springfield, VA, Rept. No. WIN-73-070 (October 1973).

60A. Healer, J., "Review of studies of people occupationally exposed to radiofrequency radiations." IN: Biological Effects and Health Implications of Microwave Radiation— Symposium Proceedings (Cleary, S.F., ed.), Richmond, Sept. 17-19, 1969 (BRH/DBE Rept. No. 70-2), 90-97.

61. Ho, H.S., "Contrast of dose distribution in phantom heads due to aperture and plane wave sources." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:454-472, February 28, 1975.

62. Huddleston, G.K., & McRee, D.I., "A pyroelectric probe for measurement of microwave power density under far-field conditions." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:510-526, February 28, 1975.

63. Hunt, E.L., King, N.W., & Phillips, R.D., "Behavioral effects of pulsed microwave radiation." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:440-453, February 28, 1975.

64. Hunt, E.L., King, N.W., & Lovely, R.H., "'Avoidance' by rats of a 2.88 GHz pulsed microwave field." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 192 only.

65. Illinger, K.H., "Interaction between microwave and millimeter-wave electromagnetic fields and biological systems: molecular mechanisms." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 160-172.

66. Iwanovsky, A., & Dodge, C.H., "Electrosleep and electroanesthesia— Theory and clinical experience," Library of Congress, Foreign Science Bulletin, 3(2): 1-64, 1968.

67. Johnson, C.C., & Guy, A.W., "Nonionizing electromagnetic wave effects in biological materials and systems," Proc. of the IEEE, 60(6):692-718, June 1972.

68. Johnson, C.C., Durney, C.H., Lords, J.L., and Livingston, G.K., "Discussion paper: Fiberoptic liquid crystal probe for absorbed radio-frequency power temperature measurement in tissue during irradiation." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:527-531, February 28, 1975.

69. Johnson, C.C., J. of Microwave Power, 8(3/4):367-388 (1973) "Research needs for establishing a radio frequency electromagnetic radiation safety standard" (Based on Report of the American National Standards Institute Committee C95 on RF Radiation Hazards, Subcommittee C95.4 on Safety Levels and/or Tolerances with Respect to Personnel); and "Brief Communication" containing comments, clarifications and additional specific research needs, J. of Microwave Power, 9(3):219-220 (1974).

70. Johnson, C.C., "Recommendations for specifying EM wave irradiation conditions in bio-effects research," J. of Microwave Power, 10(3):249-250 (Sept. 1975).

71. Johnson, R.B., Meyers, D., Guy, A.W., Lovely, R.H., & Galambos, R., "Discriminative control of appetitive behavior by pulsed microwave radiation in rats." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 37-38.

72. Justesen, D.R., Levinson, D.M., & Justesen, L.R., "Psychogenic stressors are potent mediators of the thermal response to microwave irradiation." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 134-140.

73. Justesen, D.R., "Toward a prescriptive grammar for the radiobiology of non-ionising radiations: Quantities, definitions, and units of absorbed electromagnetic energy——An essay," J. of Microwave Power, 10(4):343-354 (1975).

74. Kalyada, T.V., Fukolova, P.P., and Goncarova, N.N., "Biologic effects of radiation in the 30-300 MHz range." IN: Biologic Effects and Health Hazards of Microwave Radiation, (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 52-57.

75. Kapeluszny, A., "Protection of the natural environment against the harmful effects of electromagnetic fields in the frequency range of 0.1 MHz and 300 GHz," Wiadomosci telekommunkacyjne, No. 8, 41-56, 1974 (JPRS #64532 pages 53-65).

76. Karsovnik, S.A., et al., "Influence of electromagnetic fields in the 3 cm range on the leukocytes of animals administered Pentoxil," Biologicheskiye nauki, No. 5, 139-140, 1975.

77. Kiselev, R.I., & Zalyubovskaya, N.P., "Effect of millimeter electromagnetic waves on cell and certain cell structural elements," Uspekhi fizicheskikh nauk, 110(3):464-466, 1973.

78. Klimkova-Deutschova, E., "Neurological findings in persons exposed to microwaves." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski,

78. (cont.)- P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 268-272.

79. Koldayev, V.M., "Effects of ephedrine and nikethimide on microwave exposed mice," Byulleten' eksperimental'noy biologii i meditsiny, No. 3, 79-80, 1974, (JPRS #64532).

80. Kramar, P.D., Emery, A.F., Guy, A.W., & Lin, J.C., "The ocular effects of microwaves on hypothermic rabbits: a study of cataractogenic mechanisms." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:155-165, February 28, 1975.

81. Krueger, W.F., Giarola, A.J., Bradley, J.W., & Shrekenhamer, A., "Effects of electromagnetic fields on fecundity in the chicken." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:391-400, February 28, 1975.

82. Kulikovskaya, Ye.L., Protection From the Action of Radiowaves. "Sudostroyeniye" Press, Leningrad, 1970 (JPRS #52622), (152 pages).

83. Lancranjan, I., "Gonadic function in workmen with long-term exposure to microwaves," Health Physics, 29(10):381-383, 1975.

84. Landsberg, H.E., et al., (eds.), Biometeorology, 6, Part 1 (Supplement to 19, International Journal of Biometeorology, 1975).

85. Lebovitz, R.M., "Detection of weak electromagnetic radiation by the mammalian vestibulocochlear apparatus." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:182-193, February 28, 1975.

86. Lobanova, E.A., "The use of conditioned reflexes to study microwave effects on the CNS." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 109-118.

87. Ludwig, H.W., "A hypothesis concerning the absorption mechanism of atmospherics in the nervous system," International Journal of Biometeorology, 12(2): 93-98, 1968.

87A. Manthei, R.C., & Glaser, Z.R., "An examination of the sleep process of the rabbit as a function of chronic low intensity electromagnetic radiation exposure." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 192-193.

87B. Marha, K., "Microwave radiation safety standards in Eastern Europe," Transactions on Microwave Theory and Techniques, MTT-19(2):165-168 (Feb. 1971).

88. Marha, K., Musil, J., & Tuha, H., Electromagnetic Fields and the Life Environment. San Francisco Press, Inc., San Francisco, 1971, 29-58.

88A. Mason, J.F., "Germ-gas [electronic] radiation detectors," Electronics, ___:34-35, Dec. 1, 1959. (Also in: Digest of Tech Papers, Proc. of the 12th Annual Conf. on Electrical Techniques in Med. & Biol. (Schwan, H.P., Chmn.))

89. Massoudi, H., Durney, C.H., & Johnson, C.C., "Theoretical calculations of power absorbed by monkey and human spheroidal and ellipsoidal phantoms in an irradiation chamber." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 199 only.

90. McCree, D.I., "Biological effects of microwave radiation," Journal of the Air Pollution Control Association, 24:122-129 (1974).

91. McRee, D.I., Hamrick, P.E., Zinkl, J., Thaxton, P., & Parkhurst, C.R., "Some effects of exposure of the Japanese quail embryo to 2.45 GHz microwave radiation." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:377-390, February 28, 1975.

92. McRee, D.I., "Determination of the absorption of microwave radiation by a biological specimen in a 2450 MHz microwave field," Health Physics, 26(5):385-390, 1974.

93. Medici, R.G., "Effects of weak ELF electric fields on schedule-controlled behavior of monkeys." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 271 only.

94. Merritt, J.H., "Neurotransmitter Content of Mouse Brain After Inactivation by Microwave Heating." Brooks AFB, Texas, School of Aerospace Medicine, Rept. No. SAM-TR-75-217) 1974, 6 pps.

95. Merritt, J.H., Hartzell, R., & Frazer, J.H., "The effect of 1.6 GHz radiation on neurotransmitters in discrete areas of the rat brain." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 227-228.

96. Michaelson, S.M., & Dodge, C.H., "Soviet views on the biological effects of microwaves— An analysis," Health Physics, 21(7):108-111, 1971.

97. Michaelson, S.M., "Thermal effects of single and repeated exposures to microwaves." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 1-14.

98. Michaelson, S.M., Houk, W.M., Lebda, N.J.A., Lu, S-T, & Magin, R.L., "Biochemical and neuroendocrine aspects of exposure to microwaves." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:21-45, February 28, 1975.

98A. Michaelson, S.M., "Pathophysiologic aspects of exposure to microwaves." IN: AGARD Lecture Series No. 78 on Radiation Hazards (Sept. 1975), pp. 2-1 to 2-7.

98B. Michaelson, S.M., "Protection guides and standards for microwave exposure." IN: AGARD Lecture Series No. 78 on Radiation Hazards (Sept. 1975), pp. 12-1 to 12-6.

99. Mikolajczyk, H., "Number of mitoses in corneal eipthelium of experimental animals exposed to microwaves," Medycyna pracy, 21(1):15-20, 1970.

100. Mikolajczyk, H., "Microwave irradiation and endocrine functions." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 46-51.

101. Milroy, W.C., & Michaelson, S.M., "The microwave controversy," International Journal of Environmental Studies, 4:121-125, 1973.

102. Minin, B.A., Microwaves and Human Safety. Soviet Radio Publishing House, Moscow, 1974 (JPRS #65506, Vol. 1 & 2), 335 pps. total.

103. Miro, L., Loubiere, R., & Pfister, A., "Effects of microwaves on the cell metabolism of the reticulo-histocytic system." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 89-97.

104. Neuder, S.M., Hill, D.H., & Kellogg, R.B., "Power deposition in a multi-layered spherical model of the human head." IN: United States National Committee/ International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 200 only.

105. Oscar, K.J., & Hawkins, T.D., "Electromagnetic radiation effects on the blood-brain barrier system of rats." IN: United States National Committee/ International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 222 only.

106. Pazderova, J., Pickova, J., & Bryndova, V., "Blood proteins in personnel of television and radio-transmitting stations." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 281-288.

107. Persinger, M.A. (ed.), ELF and VLF Electromagnetic Field Effects. Plenum Press, N.Y., 1974.

108. Petrov. I.R., ed., Influence of Microwave Radiation on the Organism of Man and Animals. "Meditsina" Press, Leningrad, 1970, (NASA Transl. TT-F-708), 228 pages.

109. Phillips, R.D., Hunt, E.L., & King, N.W., "Field measurements, absorbed dose, and biologic dosimetry of microwaves." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247: 499-509, February 28, 1975.

110. Piotrowski, M., "Resonance method for the determination of the complex dielectric constant of biologic materials in the microwave band." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 243-253.

111. Polyashchuk, L.V., "Changes in the permeability of histo-hematic barriers under the effect of microwaves," Doklady Akademii Nauk Ukrainskoy SSR , No. 8, 754-758, 1972 (JPRS #58203).

112. Portela, A., Vaccari, J.G., & Llobera, O., "Transient effects of low level microwave radiation on bioelectrical muscle cell properties and on water permeability and its distribution." IN: "Abstracts" of the International Symposium on Biologic Effects and Health Hazards of Microwave Radiation, Warsaw, 15-18 October 1973, 26-28. (Also presented at the 1974 Rochester Conf. on Environmental Toxicity (Fundamental and Applied Aspects of Non-Ionizing Radiation), Michaelson, S.M., Chmn, 5-7 June, Univ. of Rochester, N.Y. (Proceedings in Press)).

113. Potapov, S.L., Sevast'yanova, L.A., & Vilenskaya, R.L., "Restorative processes in bone marrow in response to superhigh frequency radiation," Biologicheskiye nauki, No. 3, 46-49, 1974 (JPRS #64532).

114. Presman, A.S., Electromagnetic Fields and Life. Plenum Press, New York, 185-332, 1970.

115. Pyle, S., Nichols, D., Barnes, F.S., & Gamow, E., "Threshold effects of microwave radiation on embryo cell systems." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:401-407, February 28, 1975.

116. Rioch, D.M., "Effects of microwave irradiation on embryonic brain tissue," Institute for Behavioral Research, Silver Spring, Md., (Army Research Office Rept.), Nov. 1974.

117. Rivolier, J.R., "Research on a possible action of negative overionization on healthy humans." IN: Biometeorology (Landsberg, H.E., et al., eds.), 6, Part 1 (Supplement to 19, International Journal of Biometeorology, 1975).

118. Roberti, B., "Preliminary investigations of the effects of low-level microwave radiation on spontaneous motor activity in rats." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:417-424, February 28, 1975.

119. Romero-Sierra, C., Tanner, J.A., & Bigu del Blanco, J., "Interaction of electromagnetic fields and living systems." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 145-151.

120. Rotkovska, D., & Vacek, A., "Effect of electromagnetic radiation on the hematopoietic stem cells of mice." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:243-250, February 28, 1975.

121. Rotkovská, D., Daubek, J., Rotkovský, R., Stavratjev, M., & Vacek, A., "Non-contact determination of temperature changes in mice during microwave irradiation," Physical Bohemaslovaca, 22(4):359-363, 1973.

122. Ruggera, P.S., "Radiofrequency E-field measurements within a hospital environment," Proceedings of the IEEE Electromagnetic Compatability Symposium, San Antonio,Texas, October 7-9 (1975).

123. Ruggera, P.S., "Changes in radiofrequency E-field strength within a hospital during a 16 month period," DHEW Publ., Rockville, Md., (FDA) No. 75-8032, 1975, 57 pps.

124. Rugh, R., Ginns, E.I., Ho, H.S., & Leach, W.M., "Are microwaves teratogenic?" IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 98-108.

125. Rupp, T., Montet, J., & Frazer, J.W., "A comparison of thermal and radiofrequency exposure effects on trace metal content of blood plasma and liver fractions of rodents." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:282-291, February 28, 1975.

126. Sadchikova, M.N., "Clinical manifestations of reactions to microwave irradiation in various occupational groups." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 261-267.

127. Sagalovich, B.M., & Melkumova, G.G., "Research on the action of SHF on induced potentials of auditory centers in connection with prospects for inadequate auditory stimulation," Vestnik otorinolaringologii, No. 4, 3-8, 1974 (JPRS #64532).

128. Sances, Jr., A., & Larson, S.J., Electroanesthesia. Academic Press, N.Y., 1975.

129. Sandler, S.S., Smith, G.S., & Albert, E.N., "Electromagnetic field effects in nerve tissue," Aviation, Space, and Environmental Medicine, 46(11):1414-1417, 1975.

130. Schapitz, J.F., "Experimental investigation of effectiveness of psychophysiological manipulation using modulated electromagnetic fields for direct information transmission into the brain (experimental proceedings)," January 1974 (source unknown).

131. Schwan, H.P., "Microwave radiation: Biophysical considerations and standards criteria," IEEE Transactions on Biomedical Engineering, 19(4):304-312, 1972.

132. Schwan, H.P., "Principles of interaction of microwave fields at the cellular level." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 152-159.

133. Sevast'yanov, V.V., "A rapid method of visualizing the structure of an extremely high-frequency field," Military Medical Journal (Voen. Med. Zh.), No. 12, 53-57 (1974).

134. Servantie, B., Bertharion, G., Joly, R., Servantie, A.M., Etienne, J., Dreyfus, P., & Escoubet, P., "Pharmacological effects of a pulsed microwave field." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 36-45.

135. Servantie, B., Servantie, A.M., & Etienne, J., "Synchronization of cortical neurons by a pulsed microwave field as evidenced by spectral analysis of electrocorticograms." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:82-86, February 28, 1975.

136. Sevast'yanova, L.A., "Mouse bone marrow reactions to altered UHF irradiation," Biologicheskiye nauki, No. 6, 48-50, 1974 (JPRS #64532).

137. Shacklett, D.E., Tredici, T.J., & Epstein, D.L., "Evaluation of possible microwave-induced lens changes in the United States Air Force," Aviation, Space, and Environmental Medicine, 46(11):1403-1406, 1975.

137A. Sharp, J.C., Grove, H.M., & Gandhi, O.P., "Generation of acoustic signals by pulsed microwave energy," IEEE Transactions on Microwave Theory and Techniques, MTT-22(5):583-584 (May 1974).

138. Sierkierzynski, M., "A study of the health status of microwave workers." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 273-280.

139. Smyth, N.P.D., Parsonnet, V., Escher, D.J.W., & Furman, S., "The pacemaker patient and the electromagnetic environment," Journal of the American Medical Association, 227(12):1412 only (March 25, 1974).

140. Snyder, S.H., "The effect of microwave irradiation on the turnover rate of serotonin and norepinephrine and the effect on monoamine metabolizing enzymes," Baltimore, Md., Johns Hopkins University School of Medicine, 1971, 19 pps. (AD #729-161).

141. Stodolnik-Baranska, W., "The effects of microwaves on human lymphocyte cultures." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 189-195.

142. Stverak, I., Marha, K., & Pafkova, G., "Some Effects of various pulsed fields on animals with audiogenic eiplepsy." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 141-144.

143. Subbota, D.G., "Nonthermal action of microwaves on the organism (a review)," Voyenno-meditsinskiy zhurnal, No. 9, 39-45, 1970.

144. Swicord, M.L., Bassen, H.I., Herman, W.A., Duff, J.E., & Bing, J.R., "Methods and instrumentation for the evaluation and calibration of microwave survey instruments." IN: United States National Committee/International Union of Radio Science, Program and Abstracts of the 1975 Annual Meeting, October 20-23, 1975, University of Colorado, Boulder, 101-102.

145. Szmigielski, S., Jeljazewicz, J., & Wiranowska, M., "Acute staphylococcal infections in animals irradiated with 3 GHz microwaves." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:305-311, February 28, 1975.

146. Szmigielski, S., Luczak, M., & Wiranowska, M., "Effect of microwaves (3 GHz) on cell function and virus replication in cell cultures irradiated in-vitro." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:263-274, February 28, 1975.

147. Taylor, E.M., & Ashleman, B.T., "Some effects of electromagnetic radiation on the brain and spinal cord of cats." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247: 63-73, February 28, 1975.

148. Tengroth, B., & Aurell, E., "Retinal changes in microwave workers." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 302-305.

149. Thomas, J.R., Finch, E.D., Fulk, D.W., & Burch, L.S., "Effects of low-level microwave radiation on behavioral baselines." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:425-432, February 28, 1975.

150. Tikhonchuk, V.S., "The effects of combined SHF and gamma irradiation on hemopoiesis," Kosmicheskiye issledovaniya, No. 3, 478-482, 1974 (JPRS #64532).

151. Tolgskaya, M.S., & Gordon, Z.V., Pathological Effects of Radiowaves, "Meditsine" Press, Moscow, 1971 (N.Y. Consultants Bureau, 1973, 146 pages).

152. Tyler, P.E., ed., Biologic Effects of Nonionizing Radiation, Annals of the New York Academy of Sciences, 247, February 28, 1975, 545 pages.

153. Wachtel, H., Seaman, R., & Joines, W., "The effects of low-intensity microwaves on isolated neurons." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:46-62, February 28, 1975.

154. Webb, S.J., "Genetic continuity and metabolic regulation as seen by the effects of various microwave and black light frequencies on these phenomena." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:327-351, February 28, 1975.

155. Weiter, J.J., Finch, E.D., Schultz, W., & Frattali, V., "Ascorbic acid changes in cultured rabbit lenses after microwave irradiation." IN: Biologic Effects of Nonionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:175-181, February 28, 1975.

156. Williams, R.J., McKee, A., & Finch, E.D., "Ultrastructural changes in the rabbit lens induced by microwave irradiation." IN: Biologic Effects of Non-ionizing Radiation (P.E. Tyler, ed.), Annals of the New York Academy of Sciences, 247:166-174, February 28, 1975.

157. Yagi, K., Ueyama, R., Kurohane, S., Hiramine, N., Ito, H., & Umehara, S., "Harmful effects of microwave radiation on the bone marrow." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 75-88.

158. Yakovleva, M.I., Physiological Mechanisms of the Action of Electromagnetic Fields. "Meditsina" Publishing House, Leningrad, 1973.

159. Zaret, M.M., "Selected cases of microwave cataract in man associated with concomitant annotated pathologies." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 294-301.

159A. Zeman, G.H., Chaput, R.L., Glaser, Z.R., & Gershman, L.C., "Gamma-aminobutyric acid metabolism in rats following microwave exposure," Journal of Microwave Power, 8(3):213-216 (1973).

160. Zydecki, S., "Assessment of lens translucency in juveniles, microwave workers, and age matched groups." IN: Biologic Effects and Health Hazards of Microwave Radiation (Czerski, P., et al., eds.), Proceedings of an International Symposium. Warsaw, 15-18 October 1973. Polish Medical Publishers, 1974, 306-308.

161. Unsigned. "Tissue studies without hot spots," Medical World News, 15(26): 13 only (July 5, 1974).

162. Unsigned. Summaries of the 3rd International Symposium on Electrosleep and Electroanesthesia, IESA Information, No. 16, October 1972, 1-31.

163. Program and Abstracts of the 1975 Annual United States National Committee/ International Union of Radio Science (USNC/URSI) Meeting, October 20-23, 1975, University of Colorado, Boulder.

164. Unsigned. "Control of Hazards to Health from Microwave Radiation," Departments of Army and the Air Force, Washington, DC, December 6, 1965 (TB MED 270/AFM 161-7).

165. "Biological effects of electromagnetic radiation: A digest of current literature and a form of communication," Kleinstein, B.H. (Ed.), Science Information Services, Franklin Institute Research Laboratories, Vol. 1 (1974), Vol. 2 (1975).

---

*Present Address: National Institute for Occupational Safety and Health, Priorities and Research Analysis Branch of the Division of Criteria Documentation and Standards Development, 5600 Fishers Lane, Park Bldg., Room 3-50, Rockville, MD 20852.

**Ref. 52 note: Since the submission of this paper, the Seventh and Eighth Supplements have been completed (available as AD #A025-354, May '76 and AD #A029-430, August '76, respectively). These reports bring the number of citations almost to 4100. Additionally, an integrated compilation of the original Bibliography and the first seven supplements is in press (Sept. '76). Plans are to continue to update the Bibliography periodically.